REPORT DOCUMENTATION PAGE

AFRL-SR-BL-TR-01-

0638

88

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
15-08-2001	Final Technical Report	May 1998 - May 2001

4. TITLE AND SUBTITLE
Developing Adaptive Teams:
Training Strategies, Learning Processes, and Performance Adaptability

5a. CONTRACT NUMBER

5b. GRANT NUMBER
F49620-98-1-0363 (P00002)

5c. PROGRAM ELEMENT NUMBER

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

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Arlington, VA 22203-1977

10. SPONSOR/MONITOR'S ACRONYM(S)
AFOSR/NL

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution Statement A. Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This report documents a research program that is designed to advance understanding of fundamental principles of human learning and team processes that underlie individual and team adaptability. The program goal is to develop principles for training adaptive performance skills quickly, efficiently, and effectively. These principles are intended to provide a basis to guide the design of instructional tools and simulation systems for training teams that operate in dynamic and complex environments, and specify instructional capabilities that can be embedded in operational systems to enable training anytime and anywhere. Primary research objectives were to: (a) create measurement tools for modeling individual- and team-regulatory processes, (b) identify antecedents that affect the quality regulatory processes and their interplay at the individual and team levels, and (c) map the effects of experimental training strategies and individual differences on individual- and team-level regulatory processes, learning, and performance. Research findings provide an initial basis to derive theoretically based and practically relevant training principles that enhance understanding of team regulation, learning, and adaptability, and have the potential to improve team training design and training systems.

15. SUBJECT TERMS
Team Training, Team Performance, Performance Adaptability

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (include area code)
U					Steve W. J. Kozlowski 517-353-8924

Developing Adaptive Teams: Training Strategies, Learning Processes, and Performance Adaptability

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Final Report

15 August 2001

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Developing Adaptive Teams: Training Strategies, Learning Processes, and Performance Adaptability

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Summary of Project Objectives

Problem Background

Many critical command, control, and communication (C^3) activities are accomplished by individuals operating in teams and interacting via complex, technology mediated systems. These dynamic decision making (DDM) task environments place high demands on operator skills and capabilities. DDM tasks are dynamic, ambiguous, and emergent. They necessitate rapid situation assessment, prioritization, and strategy implementation. And, they require that individuals and teams adapt their performance as the situation shifts and unfolds—often unexpectedly. *Improving team effectiveness for DDM tasks requires training and team development tools, techniques, and interventions that enhance adaptive performance.*

This research program is designed to advance understanding of fundamental principles of human learning and team processes that underlie adaptability. Its goal is to develop principles for training adaptive performance skills quickly, efficiently, and effectively. These principles are intended to provide a basis to guide the design of instructional tools and simulation systems for training DDM teams, and specify instructional capabilities that can be embedded in operational systems (i.e., embedded training) to enable training anytime and anywhere Kozlowski & DeShon, 1998).

Research Objectives

From both scientific and practical perspectives, the key research problems are (a) modeling the processes of individual and team learning that yield *adaptive performance* and (b) identifying antecedents that influence its development. Both problems are virtually uncharted in the literature. First, although there is a substantial literature on learning and instructional design, it is primarily based on research using simple tasks. It provides little insight into training for complex, dynamic, cognitively loaded DDM tasks where adaptability is at a premium. Second, although there is an emerging literature on team training design (Kozlowski & Bell, in press), team training largely consists of putting teams together to practice

with the faith that they will develop the necessary skills to successfully coordinate their individual performances. The objective of this research program is focused on understanding the process of team learning and performance adaptability, and developing tools to promote it.

Research Approach

The research combines three theoretical foundations. First, the fundamental psychological mechanisms underlying cognitive, behavioral, and affective self-regulation provide a means to model individual learning and performance. Second, theories of instructional design provide a basis to develop training strategies with the potential to influence these core psychological constructs and processes. Third, team learning, performance, and adaptability represent a multilevel process that necessitates research attention to not just the individual *or* the team, but to both the individual *and* team levels (Kozlowski & Klein, 2000). By applying multilevel theory, we develop parallel analogues of individual regulatory processes at the team level. There is virtually no extant theory or research on team-regulation.

At its most elemental level, regulation involves monitoring the differences between goals and current states. Discrepancies induce evaluation and, depending on affective reactions, reallocation of attention and effort to move closer toward goal accomplishment. The research is focused on the allocation of resources (attention and effort) to both the individual and team levels. The research paradigm employs a low physical fidelity, high psychological fidelity AWACS simulation and is predicated on (a) creating measurement tools to model individual and team-regulation, (b) identifying antecedents that affect regulatory processes (i.e., individual differences, team characteristics, and situational demands) and examining the interface between individual and team regulation, and (c) mapping effects on learning, performance, and adaptability at the individual and team levels. The following sections of this report document the theoretical approach, basic research paradigm, and findings of the work conducted thus far.

In summary, the purpose of this research program is to develop and validate theoretically based and practically relevant training principles that enhance understanding of team regulation, learning, and adaptability. The principles will have the capacity to (a) guide the design of simulation systems for training, and (b) specify embedded training capabilities/features for operational systems.

Overvie w

The Nature of Performance Adaptability

Dynamic problem situations create challenges for decision makers and place a premium on the capability to adapt individual and team performance to the shifting demands of the emerging problem situation (Orasanu & Connolly, 1993). The problem is ill-structured, with incompatible or shifting goals. Diagnostic information is difficult to obtain, and is often ambiguous or conflicting when it is available. The situation is dynamic and emergent, responsive to decision maker actions, but also subject to unpredictable shifts. Individual decision makers are embedded in teams, and must coordinate their individual efforts with multiple players. Often there are significant time pressures and high stress.

Thus, DDM situations call for more than the static and routine application of well-learned knowledge. Such situations necessitate what Holyoak (1991) describes as adaptive expertise, and what we refer to as adaptability or adaptive performance. Adaptive performance builds on a foundation of basic domain knowledge and the routine expertise that guides performance in typical situations. However, adaptive performance goes beyond procedural knowledge of an automatic sort. It requires active cognitive monitoring to develop a deep comprehension of the conceptual structure of the problem domain. Adaptive experts understand when and why particular procedures are appropriate, and also when they are not. Comprehension entails mindful processing, allowing adaptive experts to recognize shifts in the situation that necessitate adaptability (Smith, Ford, & Kozlowski, 1997). From a training perspective, a key feature of adaptability is the capability of trainees to go beyond skill replication. They must also be able to generalize knowledge and skills acquired in training to situations that are more difficult, complex, and dynamic. The focus of transfer is on skill generalization, not reproduction.

A key factor for the development of adaptive performance skills is active learning during skill acquisition. Active learning enhances the development of metacognitive and self-regulatory skills. Metacognition refers to executive-level processes entailing knowledge, awareness, and control of cognitive activity involved in goal attainment (Flavell, 1979). Self-regulation occurs at a more micro-level, and entails the planning, monitoring, and adjustment of cognitive and task strategies necessary to

accomplish subgoals. In addition to cognitive and task-relevant strategies, self-regulatory skills entail the capability to manage affect. Complex tasks require focused attention and cognitive effort. Tasks that are difficult mean many errors and frustrations early in the learning process. The negative affect that accompanies failure to meet expectations draws attention away from the task and must be managed. Effective management of the learning process enhances self-efficacy, a sense of self-perceived task competency that allows the individual to tackle difficult tasks and persist in the face of novel challenges. These capabilities are also important for maintaining motivation under challenging and shifting performance conditions (Bandura, 1991; Bandura & Wood, 1989).

For teams, metacognitive and regulatory processes must extend beyond the self. That is, these individual-level cognitive and behavioral skills must operate in a coherent fashion across the team. Individuals must maintain an awareness of self within the network of roles that comprise the team. They must monitor the rhythm, timing, and pacing of team activity to enable coordination. They must monitor the performance of critical interdependent roles, and be prepared to step in and share the workload when teammates become overloaded. They must build and maintain a sense of team efficacy to deal with challenges. And they must be capable of revising tasks, roles, strategies, and goals across the entire team when the situation demands adaptation on-the-fly (Kozlowski, Gully, Nason, & Smith, 1999).

Clearly, adaptive performance skills are critical to the effectiveness of individuals and teams operating in DDM environments. Active learning needs to be stimulated during skill acquisition to enable individuals and teams to generalize under transfer. What theories of learning, training, and development can guide this process?

Theoretical Foundation

A solid theoretical foundation is central to the approach of our research program. Three theoretical legs support this effort. The first leg is formed by basic theory pertaining to fundamental psychological processes involved in learning, motivation, and performance—theories of action initiation and self-regulation of cognition, behavior, and affect. This leg is at the core of our research effort. The second leg is formed by theories of instructional design, particularly those that address the development

of individual-level adaptability and skill generalization. This leg allows us to identify instructional interventions with the potential to influence core psychological constructs and processes. The third leg is formed by broader meta-theories or heuristics that address the training and development of adaptive teams, and multilevel issues. This leg provides a framework for determining how individual-level learning and performance translate into team-level processes and outcomes. Together, these three theoretical legs provide an integrated foundation for our research addressing the development of teams with adaptive performance skills. We briefly describe each of the theoretical perspectives below.

Self-regulation. The dominant paradigm in current research on the initiation and control of action is termed self-regulation theory. Self-regulation theory has developed a broad base of empirical support as an effective model of the cognitive, behavioral, and affective mechanisms that contribute to learning and task performance. Although there are several different models of self-regulation, the models converge around key features of a process that sketches the paradigm. In essence, individuals regulate their attention and effort around goals that are either self-set or influenced by the environment (e.g., what an instructor says, what a system prompts). Feedback indicates the degree of discrepancy between current performance and the goal. Moderately negative discrepancies are affectively unpleasant and generally prompt additional effort or a revision of strategy to close the gap between performance and the goal. Substantially negative discrepancies are very unpleasant and may prompt withdrawal of attention and effort—the individual gives up. Positive discrepancies are pleasant and may prompt coasting or the reallocation of attention to another goal. In sum, self-regulation describes a cyclical, iterative process involving cognitive, behavioral, and affective elements underlying skill acquisition. As a general model of learning and task performance, self-regulation theory has amassed considerable support (e.g., Karoly, 1993).

Self-regulatory theories form the core of our research effort. They are the source of fundamental psychological constructs, and structure the mechanisms used to understand the process of learning, training outcomes, and adaptive performance. These constructs and mechanisms are the raw material to be leveraged by instructional design.

Training and instructional design. As we noted previously, the development of adaptive performance skills is predicated on active learning. Active learning necessitates instructional experiences that promote mindful processing, deliberate learning strategies, and deep comprehension (Smith et al., 1997). Although a wide range of instructional tools intended to prompt active learning have been proposed, including learner control (Steinberg, 1977, 1989), error-based training (Frese & Altman, 1989), and mastery vs. performance states (Ames & Archer, 1988), these are simply isolated tools. An integrative framework is needed to guide the use of these techniques to promote adaptive performance skills (Kozlowski, 1998).

The framework we use to guide our research provides this integration (see Kozlowski, Toney, Mullins, Weissbein, Brown, & Bell, 2001b). First, it is designed to selectively influence the self-regulatory process to influence learning, skill acquisition, and adaptive performance. In this regard, it identifies a range of instructional design constructs that can leverage the regulatory process, including the design of practice scenarios, the nature of goals and goal states, characteristics of feedback, and the role of individual differences in combination with instructional features. Thus, it meshes well with the core theoretical foundation of our approach, self-regulation. Second, it incorporates a range of outcome constructs that are designed to tap the cognitive, behavioral, and affective aspects of the regulatory process during skill acquisition. It also incorporates a distinction between routine training performance and adaptive performance skills that must manifest under more difficult, dynamic, and complex conditions. Thus, it provides guidance for research design, measurement, and evaluation in our work. And, third, the research and application logic of the framework makes a distinction between basic research designed to examine the pure effects of instructional constructs, and application-oriented research designed to examine the effects of several instructional constructs that have been combined into a training strategy. Basic research is focused on determining whether an instructional intervention has effects, and whether those effects conform to theory. Research focused on the efficacy of a training strategy is concerned with the combined effect of several interventions intended to have synergistic effects. Thus, the framework provides a means to help bridge basic research findings to application.

Team development. Finally, because our work is intended to inform the development of adaptive *teams*, we have to be sensitive to individual learning and development in the team context. It is axiomatic that learning is an individual level phenomenon; teams don't learn, individuals do. Our core model of self-regulation describes individual learning and performance. However, the relevant question is how this A self-regulatory process unfolds when the individual is part of a team that is striving to accomplish both individual and team goals? Teams provide a context for individuals. Team level phenomena such as performance are created by individual interactions, but team level phenomena also have a significant influence on individuals. Thus, the issues here are two-fold. First, an understanding of how teams normatively develop provides a basis for identifying what kind and when leverage can be best exerted in training (Kozlowski et al., 1999). Second, an appreciation of levels of analysis issues in research design and analysis allows us to tease apart individual, individual in context, and team level effects (Kozlowski & Klein, 2000). In the context of team training, both frameworks suggest the use of training strategies that (a) shift from basic to strategic to adaptive knowledge and skills, and (b) shift from individually focused self-regulation to team focused regulatory processes over time. Thus, this theoretical leg helps to ensure that learning—which is an individual level activity—is linked to team development and team performance outcomes.

Research Model

The research model, shown in Figure 1, captures the three major construct domains central to this project. *Antecedents* represent characteristics of the situation, team, and individuals that affect learning processes (regulatory activity)—at the individual and team levels. These factors, as a set, comprise the training or learning environment. Situational demands represent training design features that influence the locus of attention and effort. Individual differences represent cognitive and dispositional factors that influence learning styles and preferences. Team characteristics represent variation in the homogeneity-heterogeneity of individual differences across the team that can affect the team as a collective. *Regulatory processes* form the core of the model, and represent the means by which individuals and teams allocate attention to learning the task (monitoring/cognition), evaluate learning progress (evaluation/affect), and

take action to accomplish learning goals (action/behavior). Regulatory processes are a consequence of the constellation of antecedents, and are proximal causes of learning and performance outcomes. *Adaptive performance* constitutes the criterion domain of interest. Basic task performance forms the foundation for adaptive capabilities. Dynamic and emergent situations, however, also necessitate the capability to use appropriate prioritization strategies—to direct attention to the most serious threats—and appropriate resource allocation strategies—to distribute scarce cognitive and behavioral resources to maximize performance impact. At the team level, adaptive performance also involves the capability of the team as a whole to adjust coordination to meet emerging task demands.

Configuring antecedents to influence the nature and quality of regulatory activity is central to enhancing the learning process; this necessitates an understanding of regulation at the individual and team levels. To do so effectively, we must first understand the process of regulation at the individual level (self-regulation). Self-regulation refers to the cognitive and affective processes that activate and maintain goal-oriented actions (Meece, 1994; Schunk, 1994). Self-regulation enables an individual to guide goal directed actions over time and across dynamic situations by controlling thoughts, attention resources, and affect through deliberate use of strategies and metacognitive skills (Karoly, 1993). Self-regulation is initiated whenever goals are made salient (self set goals or externally assigned goals) or when barriers to goal achievement are encountered. Numerous models of self-regulation exist (e.g., resource allocation theory, social cognitive theory, goal setting, and control theory), but all share a core set of concepts and processes which can be abstracted to form a paradigmatic model.

In essence, the process of self-regulation refers to the establishment of goals (either self set or externally assigned), monitoring the efficacy of behaviors directed at achieving the goal through the use of feedback, and reacting affectively, cognitively, and behaviorally to perceived goal discrepancies. Three processes, operating in a cyclical fashion, regulate behavior to increase the probability of goal attainment. First, when attempting to achieve goals it is necessary to attend to feedback that is diagnostic of current performance relative to the goal state. *Self-monitoring* is the process that detects current state-goal discrepancies and prompts strategy search or development aimed at reducing the goal discrepancy.

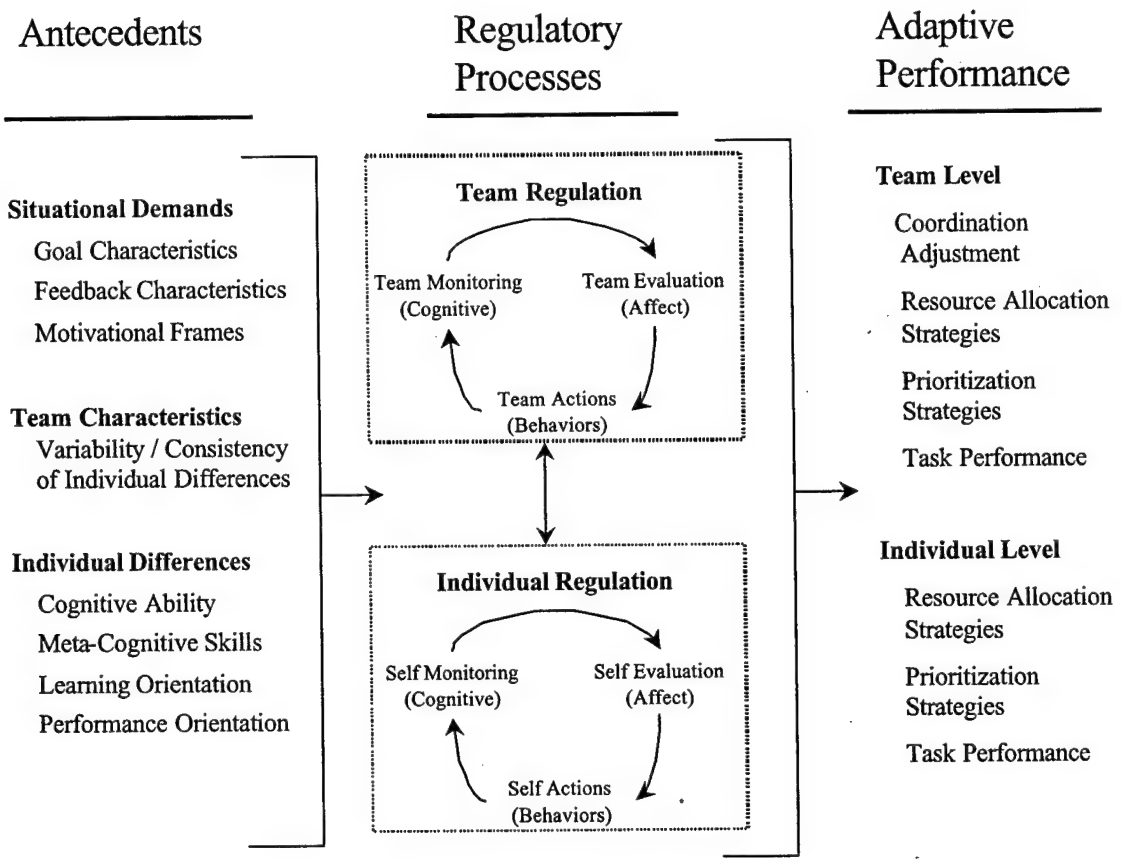

Figure 1. An Integrative Model of Antecedents, Individual- and Team-Regulatory Processes, and Adaptive Performance

Second, *self-evaluation,* includes both affective reactions to feedback and self-efficacy judgments. Learning complex tasks requires focused attention and cognitive effort and often results in many errors (discrepancies). The negative affect that accompanies failure to meet expectations draws attention away from the task and must be managed. Effective management of the learning process enhances self-efficacy, the sense of perceived task competency that allows the individual to tackle difficult tasks and persist in the face of novel challenges. These capabilities also play an important role in maintaining motivation under challenging performance conditions (Bandura, 1991; Bandura & Wood, 1989) and provide a

foundation for individual adaptability (Kozlowski et al., 1995; Smith et al., 1997). Finally, *self-actions* refer to the cognitive processes used to develop and evaluate strategies designed to reduce goal discrepancies and the behavioral manifestations of these cognitions (e.g., allocate more effort to the task, shift strategy). The results of self-actions provide feedback for input into the next cycle of the self-regulatory process.

Self-regulation in a team context. Two distinct types of behavioral regulation occur when individuals function in a team to achieve team goals. The first type of regulation is best conceived of as self-regulation in a team context. To understand the effects of this form of self-regulation, it is necessary to recognize that individuals regulate behavior around multiple, hierarchically structured goals (Carver & Sheier, 1990). In team settings, the team goal can be thought of as the highest order goal in the goal hierarchy and all lower level goals are conceived of as subgoals that must be accomplished to achieve the team goal. Teams are invariably formed to accomplish tasks and therefore, these goals are oriented toward specific task performance. Teams develop strategies for achieving the goals such as resource allocation across team members, pacing of information among team members, and communication protocols. In addition, team members have specific roles and the goals associated with these roles must be met in order to meet the team goals. Finally, at the lowest level in the team goal hierarchy, are the goals of the individual.

Research on goal hierarchies suggests that the focus of self-regulation moves flexibly up and down the goal hierarchy in response to detected discrepancies (Lord & Levy, 1994). This implies that individuals must monitor team performance to detect team goal discrepancies, react to the team goal discrepancies, and then take action either at the role or individual goal level to reduce the team discrepancy. Clearly, self-regulation in team contexts is a complex process since there are likely to be multiple team goals, multiple individual goals, and individuals are likely to have more than one role in a team. However, the basic process described previously should operate similarly for multiple goals within a particular level in the goal hierarchy. Also, it should be emphasized that self-regulation occurs within individuals—it is the focus of the regulation that distinguishes teams and individuals. This form of self-

regulation represents a multilevel perspective of processes that occur within an individual that are oriented toward a higher-level process; in this case, teams.

Team-regulation. The second form of regulation that occurs when individuals operate in a team structure represents the behavioral and cognitive interactions that occur among team members and is a qualitatively distinct team level phenomenon. *Team-regulation* may be understood by developing analogs of the basic self-regulatory processes of self-monitoring and self-reactions. When functioning in a team context, it is not enough to monitor one=s own performance level. Instead, for a team to perform well, team members must monitor the other team members= performance to detect team goal discrepancies and provide mutual error correction to reduce the discrepancy (Fleishman & Zacarro, 1992; Nieva, Fleishman, & Rieck, 1978; Shiflett, Eisner, Price, & Schemmer, 1982). They must pace their performance output so that other team members receive the correct information when it is most relevant and can be used in an efficient manner. In addition, it is often necessary for team members to detect when another team member is overloaded by a task and to aid the team member by sharing the workload whenever possible. For these interactions to occur, the team members must not only monitor their own behavior, they must also attend to the performance of the other team members and the team as a whole to insure that the team goal is achieved. For this to occur, the team members must understand how each team member's role relates to the overall team goal and, when the team goal is not being achieved. They must direct effort to aid other members or the team as a whole to ensure collective effectiveness.

The second aspect of the team level regulation is concerned with collective reactions to team goal discrepancies. In DDM contexts, the relationship of available feedback with the team goal is rarely unambiguous. Therefore, team members often need to interact to make sense of the feedback as a group and to determine the implications of the feedback for progress toward the team goal. This social-cognitive sense making process (e.g., Bandura, 1986) results in consensus on feedback and affective reactions. Otherwise, team members might interpret and react to feedback differently and, as a result, behave in unpredictable ways. The shared interpretation of feedback with respect to the team goal is also important so that team members develop a sense of team efficacy. This construct is directly analogous to self-

efficacy but refers to team members' shared perceptions of the *team's* ability to achieve goals in a particular setting. As with self-efficacy, team-efficacy is related to team persistence in the face of repeated negative feedback and accounts for team performance beyond the self-efficacy perceptions of the team members (e.g., Gully, 1997; Prussia, & Kinicki, 1996). This second form of team-regulation, which has received virtually no research attention, represents a true composition model whereby individual level processes interact to form a team level phenomenon; the same basic process occurs at both levels of analysis, but the focus of the process and the cognitive content upon which the process operates differs across levels of analysis.

Research Focus

The research objective is focused on understanding the process of team learning and performance adaptability, and developing tools to promote it. Guiding theory is drawn from the domains of instructional design (Kozlowski et al., 2001b; Smith et al., 1997) and levels of analysis (Kozlowski & Klein, 2000) around a core framework of individual- and team-level regulatory processes underlying skill acquisition and adaptability. The goal is to develop and validate theoretically based and practically relevant training principles that enhance individual and team regulation, learning, and adaptability.

Research Program Summary

Research Approach and Paradigm

Our research is predicated on (a) creating measurement tools to model individual and team-regulatory processes, (b) examining the interface between individual and team regulation, (c) identifying antecedents that affect regulatory processes (i.e., situational demands, individual differences, and team characteristics), and (d) mapping effects on learning and performance at the individual and team levels. Accomplishing this research necessitates the use of a synthetic task environment to emulate key characteristics of team DDM situations. Our research paradigm employs a low physical fidelity, high psychological fidelity AWACS simulation, TEAMSim.

One of the principal challenges for the use of synthetic tasks in research is the degree of fidelity—high vs. low—of the synthetic task relative to its real world counterpart. High fidelity

simulations are often presumed to be superior. By emulating the physical characteristics of the real world task as closely as possible, the presumption is that high fidelity simulations resolve the "transfer problem." That is, their use enables research findings to be better extrapolated to the operational environments that they emulate. In contrast, our approach focuses on psychological fidelity in training design. *Psychological fidelity* concerns the extent to which the training environment prompts the essential underlying psychological processes relevant to key performance characteristics in the real-world setting. In other words, it is an effort to evoke the central psychological constructs and mechanisms responsible for on-the-job performance. Whereas the physical fidelity approach attempts to accomplish this *implicitly* by *replicating the performance environment*, the psychological fidelity approach represents an effort to model this *explicitly* by *using basic theory to guide research and training design.* By doing so, it has the potential to enable the use of cost-effective low fidelity simulations during training that can nonetheless maximize transfer in terms of retention and, more importantly, generalization. Documentation of our approach and paradigm—links to theory, construct measurement, task construction, and research design—is detailed Appendix A.

Constructing Training Strategies: Effects of Antecedents on Regulatory Processes

Situational demands. A number of situational, individual level, and team level factors affect the quantity and quality of the self-regulatory process. The primary situational factors that have been demonstrated to affect self-regulation and learning are feedback, goals, and motivational frames (Kozlowski et al., 2001a). The model of self-regulation indicates that without performance feedback there can be no effect of goals since there is no information on which to base discrepancy judgments. This concept has been demonstrated empirically (e.g., Bandura & Cervone, 1983, 1986). Moreover, preliminary evidence shows that the level of feedback (e.g., team vs. individual) can affect the focus of regulatory activity (Gully, 1997). So, for instance, regulation around team goals may be undermined by only providing feedback on individual performance. Or, individual performance may be compromised by the provision of team feedback. This is an important consideration in the design of team training strategies—at what level should feedback be directed? Existing self-regulatory models of learning and

performance (Carver & Scheier, 1998) suggest that providing feedback on both individual and team performance should result in substantially improved individual and team performance. However, it is possible that providing both team and individual feedback could overwhelm the participants' limited cognitive resources and result in performance decrements. If so, it is important to determine which type of feedback is optimal under what circumstances.

Experiment 1 is designed to examine the effects of the level of performance feedback—individual, team, or both—on the quality of regulatory activity and performance outcomes. Two hundred thirty seven participants were formed into 79 three-person teams operating TEAMSim in an AWACS emulation. Participants in the individual feedback condition received information about their own performance but not their team's performance. Individuals in the team feedback condition received feedback on their team's performance but did not receive information on their contribution to team performance. Individuals in the combined feedback condition received information on their individual performance and their team's performance. Participants completed three blocks of two trials, with each trial consisting of a cycle of study/preparation, task performance, and feedback. Various team and individual regulatory process measures were collected throughout the experiment.

Key findings from this research indicated that receiving feedback only on individual performance maximized individual performance. Similarly, receiving team only feedback maximized team performance. Receiving both individual and team feedback did not result in better individual or team performance. That is, receiving both levels of feedback did not result in better individual performance than when only team feedback was provided. Similarly, receiving both levels of feedback did not improve team performance in comparison to the group only receiving individual feedback. In other words, individuals were not able to make effective use of both levels of feedback. The impact of feedback on performance occurred through effects on self-regulatory process variables such as the investment of effort, increased goal setting, higher levels of self-efficacy, and the development of strategies. Based on these results, it does not appear that individuals are able to utilize the potential benefits of receiving both individual and team feedback. Instead, it is best to provide either team or individual feedback depending

upon the desired focus of attention. If the goal is to promote the development of individual performance, individual performance feedback should be provided. If the goal is to promote the development of team performance, team performance feedback should be provided. Thus, the following training principle is suggested based on these results:

> ***Principle:*** *During early learning and skill acquisition, the level of feedback information to trainees in teams should be targeted to the desired level of regulatory focus—individual or team. Simultaneous feedback at both the individual and team levels is not advised.*

Detailed documentation for Experiment 1 appears in Appendix B.

The results of the prior experiment suggest that rather than inducing simultaneous regulatory processes at the individual and team levels, it might be more effective to direct regulatory attention and effort in a sequence that develops appropriate adaptive skills first at the individual and then team levels (Kozlowski et al., 1999). In addition, feedback is merely one technique for influencing regulatory focus. Research has repeatedly demonstrated that the type of goal (e.g., learning vs. performance), the difficulty of the goal, and the timing of the goal assignment affects the learning process (DeShon & Alexander, 1996; Kanfer & Ackerman, 1989; Kozlowski et al., 1995, 1996, 2001a; Locke & Latham, 1990). There is also limited evidence that the relative focus of goals at the team or individual level affects self-regulation and learning across levels (Gully, 1997).

From a team development perspective, Kozlowski et al. (1999) assert that the focal level of developmental progress should shift across levels over time as skills compile from the individual to the team level. Individuals first need to focus attention and effort on the development of their own skill proficiency. Attention to the team can be expected to draw essential self-regulatory resources needed for basic task comprehension and skill acquisition. As individuals acquire the basic skills needed for individual proficiency, their level of focus then needs to shift to learning how to coordinate as a team and to make progress toward team objectives. By directing attention to regulating around team-level skills, individuals are expected to maintain their proficiency and to develop essential skills for team adaptability

and effectiveness. A key mechanism for promoting this shift is the focal level of regulatory activity driven by the level of goals, individual or team.

Experiment 2 addressed this potential means to influence the regulatory process by examining the effects of shifting regulatory focus from individual goals to team goals relative to a simultaneous or holistic focus on both individual and team goals. Four hundred and eighty participants were assigned to 160 three-person teams operating TEAMSim in an AWACS emulation. Participants in the shifting regulatory focus (team compilation) condition were instructed to focus on individual goals early in training, and to shift focus to team goals later in training. In contrast, participants in the holistic focus (team building) condition were instructed to focus on both individual and team goals throughout training. Participants completed three blocks of two trials, consisting of a study/preparation period, practice, and feedback. After the training trials, teams were presented with a more difficult and complex scenario designed to test their ability to generalize skills and adapt to novel and challenging situations. Various team and individual regulatory process measures were collected throughout the study.

Key findings indicated that shifting regulatory focus from individual to team (team compilation) exhibited hypothesized effects. Trainees in the team compilation condition exhibited superior individual performance early in training, superior team performance later in training, and better adaptive performance at the end of training relative to trainees in the team building condition. Moreover, the improvements in team performance and team adaptability did not come at the expense of individual performance. Analyses to examine regulatory process variables indicated that these enhancements were accounted for by the level of regulatory focus, which conformed to the hypothesized pattern. Thus, the results provide basic support for the Kozlowski et al. (1999) normative model of team development and for the research model (Figure 1) focusing on individual and team level regulatory processes.

From an application perspective, the findings suggest that team-training strategies should be designed to shift the regulatory focus from individual to the team level. When combined with the results from Experiment 1, these findings strongly suggest that holistic approaches that attempt to focus attention

and effort on both levels simultaneously should be avoided. These findings yield the following training principle:

> ***Principle:*** *Regulatory focus should be sequenced from the individual level to the team level during the initial acquisition of team performance skills to enhance both individual and team performance and performance adaptability. Simultaneous regulation of both individual and team skill development is not advised.*

Although this principle is based on the use of goals to influence the level of regulatory focus, we would expect the principle to apply to interventions that use feedback to influence regulatory focus as well. This expectation is bolstered by the related findings from Experiment 1. Detailed documentation for Experiment 2 appears in Appendix C.

In addition to goal level, the motivational frame—the focus of the goal on learning as opposed to the more traditional focus on performance—has been demonstrated to affect the quality of the self-regulatory process (Kozlowski et al., 2001b). Training environments often explicitly or implicitly emphasize performance goals. Yet, research indicates that an orientation to performance goals during skill acquisition may hinder learning of complex task relationships (Kanfer & Ackerman, 1989; Kozlowski et al., 2001a). As individuals attempt to maximize performance, they focus on a narrow set of surface characteristics (Meece, 1994) limiting self-regulatory processes to superficial aspects of the task domain and preventing attention to deeper concepts and principles. In addition, consistent failure to reach performance goals limits the development of self-efficacy and adaptability. In contrast, an orientation toward mastery may be more effective for the acquisition of complex skills (Schunk, 1990). Mastery goals prompt a self-regulatory process centered on learning deeper task concepts and principles, with less attention devoted to superficial aspects of task performance (Karoly, 1993). A mastery goal orientation primes trainees to explore complex relations in the task, make errors, and learn from those errors. This promotes the development of coherent knowledge and self-efficacy, both of which contribute to adaptive performance at the individual level (Kozlowski et al., 1995, 2001a). Although goal orientation traits and

states are known to affect individual-level regulatory processes, how goal orientations influence regulation at the team-level is virtually unexplored.

Feedback is a factor that is likely to influence the nature and focus of regulation when trainees have to manage regulation at both the individual and team levels. Experiment 1 examined the effects of different *levels* of feedback (i.e., individual, team, or both) on the regulatory process and its focus. However, another aspect of feedback in the team context is whether it is public or private in nature; that is, whether individuals receive feedback on just their own performance (Private) or whether they receive feedback on their own performance *and* the individual performance of other team members (Public). Note that this type of feedback is not team-level feedback, rather it is individual feedback in the team context.

Private feedback is more likely to focus attention on individual regulation, and may lead to process losses at the team level; that is, individuals may limit essential contributions to team performance. In contrast, public feedback in which one's performance within the team is visible and comparable to all is more likely to focus attention on team regulation, and may lead to process gains as individuals allocate extra effort to do well themselves and to contribute to the team. These effects have generally not been examined in a group context. How they potentially combine with the influence of goal orientation to influence both individual and team regulation over time is an open question. Thus, the conceptual focus in this research is the effects of the manipulations on mediators of individual and team regulatory processes, including goal orientation states, learning, regulatory indicators, and performance.

Experiment 3 examined the effects of goal orientation induction (learning vs. performance) and mode of feedback presentation (public vs. private feedback) on goal orientation states, regulatory processes, learning, and performance. Three hundred and ninety-three participants were assigned to 131 three-person teams operating TEAMSim in an AWACS emulation. The experiment employed a fully crossed 2x2 design that manipulated goal orientation inductions (learning vs. performance) and mode of feedback presentation (public vs. private), with trainees studying, operating the simulation, and receiving feedback in three blocks of two trials each. Various measures were collected prior to and throughout the experiment.

Both manipulations combined to influence goal orientation states and the development of basic and strategic knowledge. Of primary interest, goal orientation states and knowledge in turn influenced self-regulation process indicators. As expected, state mastery orientation was associated with an adaptive pattern of self-regulation (i.e., enhanced self-efficacy, team-efficacy, strategic planning, and lower anxiety), whereas state performance-avoid orientation was associated with a maladaptive pattern of self-regulation (i.e., lower self-efficacy, team-efficacy, strategic planning, and greater anxiety). Knowledge (i.e., basic and strategic) also enhanced regulatory processes. All self-regulatory process indicators significantly contributed to enhanced individual performance. Similarly, team-level regulatory process indicators significantly contributed to enhanced team performance.

Overall, the results indicated that public individual feedback in the team context exhibited strong facilitative effects on regulatory processes at both levels. Goal orientation states and knowledge were key proximal factors influencing the quality of individual and team regulation, and that individual and team regulation were substantial predictors of individual and team performance, respectively. Public feedback evidenced key effects on inducing a mastery or learning goal orientation state in trainees, which, in turn, facilitated self-regulatory processes and performance. Surprisingly, effects of the goal orientation inductions were quite weak. Further research will be required to decompose this phenomenon. However, from an application perspective these results suggest that the provision of public individual feedback in the team context is a potentially important tool for training design, particularly since it can be easily embedded in simulation systems and other training platforms. These research findings yield the following training principle:

> ***Principle:*** *During early team skill acquisition, individual feedback should be provided in the team context (Public Feedback) to enhance individual and team regulation and individual and team performance.*

Detailed documentation for Experiment 3 appears in Appendix D.

Individual differences. A number of individual characteristics have demonstrated robust effects on self-regulation. As with virtually every learning task, individuals with high levels of cognitive ability

tend to be better at self-regulation (e.g., Kanfer & Ackerman, 1989). Individuals with high levels of self-efficacy tend to persist longer on complex tasks that often involve high levels of negative feedback. This persistence in the face of failure seems to be a result of better affect regulation and results in higher levels of learning (Kozlowski et al.,2001a, 2001b; Sitkin, 1992). There are also a number of personality traits that are related to self-regulation and learning. For example, an individual's general view of complex tasks as opportunities for learning (learning orientation) or ego threats (failure to perform) is related to persistence and task mastery (Dweck, 1986; Kozlowski et al.,1995, 2001a). In particular, research has generally concluded that a learning or mastery orientation yields an adaptive learning style, whereas a performance orientation yields a maladaptive learning style. Although goal orientation is often viewed as a set of enduring *traits*, recent research has made clear that goal orientations can be influenced as situational *states*. Relatively little work exists that addresses traits and states simultaneously in an attempt to disentangle their respective effects. Therefore, the purpose of this research was to examine the interplay of mastery goal orientation as a trait and a state in the learning process.

Experiment 4 examined the impact of mastery goal orientation trait on mastery states, the conditions under which such effects are enhanced (e.g., self-efficacy serves as a moderator), and the role of a mastery state as a mediator of mastery trait effects. This research involved a selective analysis of data from Experiment 2, controlling for the manipulations. Key findings indicated that trait mastery orientation was positively related to state mastery orientation, but the relationship was modest, indicating that one's general tendency to adopt learning goals had only a modest influence on the extent to which individuals actually adopted learning goals in the training situation utilized in this research. Self-efficacy was also found to influence state mastery orientation positively. Further, trait mastery and state mastery orientation were found to interact on state mastery orientation. If individuals had a general tendency to value learning and mastery and had confidence in their ability to learn and master the radar-tracking task in this study, they were more likely to focus on mastering this task. Finally, as expected, the effects of trait mastery orientation were fully mediated by state mastery orientation. This indicates that trait mastery orientation influences learning processes and outcomes by increasing one's tendency to adopt learning

goals in a given situation. However, given that this relationship is only modest at best, attention must be given to situational factors that influence state goal orientations. The results of the current research suggest that efforts should be made to foster self-efficacy, or trainees' belief in their ability to master the material at hand. In general, these findings provide convergent evidence on the importance of goal orientation traits, states, and regulatory processes as important factors in training effectiveness. Based on these findings, the following training principle is offered:

Principle: *Training systems should be designed to foster mastery goal orientation states and to build self-efficacy during early skill acquisition.*

Detailed documentation for Experiment 4 appears in Appendix E. In addition, *much of our research examines the effects of ability and dispositional characteristics on the nature and quality of regulatory processes.* Findings regarding individual differences are discussed where relevant in conjunction with each experiment.

Team characteristics. Finally, at the team level of analysis the mixture of individuals comprising the team has been shown to affect team performance. It is established that team-level individual differences in personality (e.g., Barrick, Stewart, Neubert, & Mount, 1998) can affect how well team members perform. Although the work addressing personality suggests some modest relationships for broad personality constructs drawn from the Big 5 (e.g., conscientiousness and agreeableness; Barrick et al., 1998), other work suggests that more targeted dispositions relevant to learning styles, such as goal orientation, may be more useful in this regard. Given the demonstrated value of goal orientation as a useful predictor at the individual level, this research sought to extend the construct to the team level.

When considering the higher level constructs that are composed from lower level elements, it is necessary to understand the nature of the composition process. Chan (1998) provided a useful typology of composition models that may be used to understand various ways in which a team-level analogue of goal orientation may be formed. Two reasonable methods of forming team-level goal orientation from individual-level data are referred to by Chan (1998) as the additive model and the referent-shift model. In the additive model, an aggregate of team members' individual scores to items that reference the self is

formed and used to represent the team-level variable. This is by far the most commonly used method for constructing higher level variables in team research. An alternative to this process is the referent-shift approach, where individual teammates provide ratings of the team (instead of themselves). These individual ratings of the team may be combined by various methods (e.g., average, variance, minimum, or maximum) to represent the team-level construct of goal orientation. The purpose of this research is to examine various methods of composing team-level goal orientation from individual-level data and to examine the relationship of team-level goal orientation with team resource allocation and individual and team performance.

Experiment 5 examined the extent to which the team-referent goal orientation (operationalized via the reference shift model) would account for significant variance in team performance beyond that accounted for by aggregated individual-referent goal orientation (additive model). A second focus was to examine the utility of alternative composition models for team-level goal orientation. One hundred and sixty-two participants assigned to 54 3-person teams operating TEAMSim in an AWACS emulation. Feedback was manipulated, but was controlled in analyses. Trainees participated in seven trials, each consisting of a cycle of studying, operating the simulation, and receiving feedback. Various measures were collected prior to and throughout the experiment.

Key findings indicated that individually referenced goal orientation, when composed to the team level, was a relatively poor predictor of team performance. The only significant relationships were evidenced for performance goal orientation such that teams exhibiting less variance or lower minimum values had better performance. Findings for the aggregated team referenced goal orientation were more robust. Team performance was strongly related to three of the four composition models for the team-referent goal orientation scales (average, minimum, and maximum). The results of this research suggest that appropriately targeted items that address the goal orientation of the team provide a useful method for characterizing the team in ways that are directly related to performance. These results are the first empirical demonstration that team-referent items can provide better prediction of team performance than various composition models of individual-referent items.

There are several implications for further research. First, it appears that the team-referent items do not have the same factorial dimensions as the individual-referent items. Either team members are incapable of distinguishing between performance and mastery orientation at the team level or these items capture something unique to the team having to do with team processes. Further research is needed to determine the cause of the high correlation between the team-referent performance and mastery orientation scales. Second, this research represents a very simple model relating goal orientation to performance. It is important to examine the relationship of goal orientation and performance in a larger model containing other variables related to team composition, team process, self-regulatory and team-regulatory behaviors and cognitions. From an application perspective, however, the results point to the value of enhancing team-level goal orientation as a means to enhance team performance. This necessitates the development of appropriate composition models of team goal orientation, and identifying factors that can influence it. The following training principle is suggested by these findings:

> ***Principle:*** *Training systems should be designed to enhance team mastery goal orientation during team skill acquisition. It is important to recognize that team mastery goal orientation is a team-level construct—distinct from individual mastery goal orientation—that has origins at the individual level (Kozlowski & Klein, 2000).*

Detailed documentation for Experiment 5 appears in Appendix F.

Discussion and Conclusion

The primary objectives of this research were to create measurement tools to model individual and team-regulatory processes, identify antecedents that affect the quality regulatory processes and their interplay at the individual and team levels, and map the effects of the antecedents on individual and team level regulatory processes, learning, and performance. Overall, the research made solid progress toward accomplishing these objectives.

We developed and elaborated the conceptual foundation (i.e., instructional design, levels of analysis, and core regulatory processes) undergirding the research approach (Figure 1), experimental simulation (TEAMSim), and measurement tools for modeling individual and team regulatory processes,

antecedents, and outcomes. Although our research, by necessity, relies on low fidelity simulation and college student trainees, this integrated conceptual foundation, experimental simulation, and set of constructs and corresponding measures is intended to enhance the potential of generalizing our findings to operational environments and personnel. By explicitly focusing on theoretically relevant psychological constructs and mechanisms—not merely on physical fidelity—we believe that we have developed a solid basis for generating generalizable principles to improve learning and training effectiveness using research derived from low fidelity simulations.

Solid progress has also been made with respect to establishing the efficacy of the research model illustrated in Figure 1. First, as expected, goals and feedback exhibit significant influences on both individual and team level regulatory processes. From an instructional perspective, the key is using these situational levers appropriately. Experiment 1 showed that feedback should be targeted at the level of regulatory activity that is of interest. If the interest is individual regulation, learning, and performance, then individual feedback is best. If the interest is team regulation, learning, and performance, then team feedback is best. Theory (e.g., Carver & Scheier, 1998) and some prior research suggesting that simultaneous regulation at both levels is desirable (Mitchell & Silver, 1990) were not supported. Experiment 2 demonstrated that appropriately shifting goal levels from individual to team level over the course of skill acquisition yielded superior team performance and team adaptability without any degradation of individual performance relative to a more holistic simultaneous focus on both individual and team goals throughout training. Because team-training environments often emphasize both individual and team performance (implicitly and explicitly), the findings of both Experiments 1 and 2 have clear implications for structuring transitions in goal and feedback levels when training in a team context. Second, goal orientation traits, states, and training interventions are important elements of skill acquisition in team contexts. Overall, mastery goal orientation traits and states generally evidenced facilitative impacts on indicators of regulatory processes (Experiments 3 and 4), with positive effects of regulatory processes on learning (Experiment 4) and performance at both the individual (Experiment 3) and team levels (Experiments 3 and 5). Thus, there is good support for our research model and approach.

There are also some unanticipated findings. Of particular interest, is the failure of goal orientation training interventions/manipulations to exert strong effects on regulation (Experiment 3). A broad base of individual level research has demonstrated fairly robust facilitative effects for mastery goal orientation interventions (see Kozlowski et al., 1995, 1996, 2001a, 2001b; Winters & Latham, 1996; Stevens & Gist, 1997). However, when coupled with public vs. private feedback in the team context, goal orientation interventions exhibited limited effects on regulatory processes, learning, and performance. It could be the case that the goal orientation manipulation was dissipated in the team context relative to individual settings. Given the consistent and robust effects for goal orientation manipulations at the individual level, and hence their instructional potential at the team level, this issue warrants further research attention. In addition, further research attention to leveraging individual regulatory processes and modeling their interplay with team regulation as a means to enhance individual and team learning is warranted.

In conclusion, good progress has been made toward the accomplishment of our primary research objectives to: (a) create measurement tools for modeling individual and team-regulation, (b) identify antecedents that affect the quality regulatory processes and their interplay at the individual and team levels, and (c) map the effects of the antecedents on individual and team level regulatory processes, learning, and performance. Our findings provide an initial basis for deriving theoretically based and practically relevant principles that enhance understanding of team regulation, learning, and adaptability.

We believe that this research stream and the derived principles have the potential to improve the design and effectiveness of team training systems. By selectively and appropriately influencing regulatory focus using goals and feedback, training sequences can be created that compile individual and team skills essential for performance adaptability. In addition, our approach provides flexibility in the delivery mechanisms for team training. Our research demonstrates that the training strategies underlying these principles can be embedded in simulation systems, and therefore also have the potential to be deployable into operational systems, enabling training to be conducted anytime and anywhere. Moreover, the principles are expected to be applicable to distributed training systems that utilize similar mediating simulations, further broadening their potential applicability and utility.

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